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ABSTRACT

The effects of exercise in children can be assessed by physiological measures of the respiratory and cardiovascular body functions and by anthropometric measures of body composition and maturation. Several methods and techniques in these areas are available to the researcher and practitioner for attempting to assess the physiological aspect of motor developmental status and progress in children. (Various methods available are reviewed including both laboratory and in-the-field tests.) (JMF)

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New Directions in Assessment: Developmental Exercise Physiology

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New Directions in Assessment: Developmental Exercise Physiology

Most children spend a large part of their waking hours in one form or another of exercise, generally much more so than adults. Our knowledge of exercise physiology, however, has grown up largely through animal and human studies, the latter carried out mainly in adult populations. It has become increasingly obvious that a knowledge of the way in which children adapt to exercise as they grow is essential for the understanding of how the adult pattern is achieved.

The relative lack of information about the effects of exercise in children reflects the general problem of making valid physiological observations in young subjects. There a a number of very practical difficulties in terms of apparatus, techniques, and obtaining the cooperation of the subjects.

It is the purpose of this paper to present a review of the various methods available for the physiological assessment of children. Since an all-encompassing description of all available equipment, each technique, is not possible, several pieces of equipment, several techniques - including some which are normally used only in the laboratory, and some which can be used away from the laboratory setting - will serve as "highlights" of the full range of techniques available for the physiological assessment of children.

Since there is a great deal of literature available in the area of physical fitness testing (Larson, 1974), this paper will deal with two specific foci: 1)physiological measures - that area of exercise physiology which seeks to assess respiratory and cardiovascular function; and 2) anthropometric measures - which seek to assess body composition and maturation.

Physiological Measures

This section deals with those methods and techniques used to assess both respiratory and cardiovascular function. In the laboratory, the two basic pieces of equipment are the treadmill and the bicycle ergometer; if neither of these is available in the laboratory, or if the testing is to be done away from the laboratory, then a bench stepping test or any one of a number of distance run tests may be used.

In any case, the overriding concern when considering techniques for the measurement of exercise effects in children is that they should be safe, acceptable to the child, and yield useful information. In other words: although there are several invasive techniques which are commonly utilized in studies of adult populations, and although these techniques yield very useful information to the researcher, the questions of safety and acceptability would in all probability eliminate them as possibilities.

As with adults, there is an increasing scale of complexity in the types of exercise tests that can be performed in children. At the simplest level, observing the child as he runs back and forth along a corridor or up and down stairs can yield valuable information. One can improve the value of these simple tests by having the child run for a standard time, or by having the child perform a modified bench-step test at a reasonably constant rate, and making simple measurements such as heart rate on stopping. If a bench-stepping test is to be utilized, care should be taken that the height of the bench is appropriate for the size of the child.

If heart rate, for example, is the measurement to be used in a field-test situation, it is not at all difficult for children to learn to count pulse rate via palpation of the radial artery.

One can also utilize a variety of distance-run tests. For example, the International Committee for the Standardization of Physical Fitness Tests (Larson, 1974) has recommended a run of 600-800 meters, with time to the nearest second to complete the run being the measure which might distinguish different levels of cardiovascular endurance among children. As another example of a field test for cardiovascular endurance, Jackson and Coleman (1976) propose a nine-minute run, with total distance covered being the criteria for determining cardiovascular endurance.

In the exercise physiology laboratory, the treadmill and the bicycle ergometer are the standard items of equipment utilized in physiological assessment.

When choosing an ergometer for children, there are several points to consider. First, it is necessary to be able to adjust the work increments according to the size and ability of the child, and not by fixed amounts which may be suitable for adults. Most ergometers now provide special low saddles for children, but it is also important to have adjustable handle-bars and pedal crank length. Unless the child is absolutely comfortable on the bicycle ergometer, he will be easily distracted and hence a poor subject.

Treadmills are more cumbersome and noisier than ergometers, but they provide a much more natural form of exercise. They are available in varying degrees of sophistication, and may cost up to three times as much as the most expensive bicycle ergometer. When testing children on a treadmill, it is essential that

the machine runs quietly, is not frightening, and is fitted with a safety harness (Godfrey, 1974) which will stop the belt and support the child if he should stumble or stop running. Good access to the child is also important.

Although treadmill speeds need not go as high as required for adult athletes, it should be noted that even eight year-olds may need to run at speeds of approximately nine miles per hour to reach their maximum oxygen uptake (Astrand, 1952); the less- expensive models, with lower maximum running speeds, therefore, may not prove adequate.

Pulse rate can be counted manually during exercise - either on a bicycle ergometer or on a treadmill - but this is quite difficult; waiting until the exercise is completed to count pulse rate may yield incorrect data, since pulse rate may well have been altered by the time it can be counted after stopping. There is really no subsitute for electrocardiograph recording during exercise, either on the treadmill or the bicycle ergometer.

Measurement of ventilation and gas exchange are the center of most laboratory experiments. There are many ways in which this can be accomplished, but all methods basically depend on the separation of inspired and expired gas, the measurement of gas volume over timed intervals, and an analysis of a representative sample of mixed expired gas. To accomplish this, there are many types of equipment available; whichever is chosen, it is important that the equipment be specifically tailored for children

One of the simplest and most informative tests that can be carried out on a child is to have him pedal a bicycle ergometer and increase the work load progressively to provide increasing stress. Over the years, all manner of progressive exercise tests have been developed for use in adult studies, and many of these have also been used to study children. The object of these tests is usually to obtain data, particularly about heart rate, at submaximal levels of work which will enable a prediction to be made about the subject's Max V_{O_2} or his working capacity at some given heart rate.

These types of progressive exercise tests can be very useful in children, but they must be modified before they can be applied. The tests are very time-consuming and require a good deal of cooperation over a long period of time. While this is readily given by adults, children easily become bored and their attention wanders.

Another problem arises because of growth; that is, a fixed increment of work will mean different things to different children. For example: a work increment that represents 20% of maximum working capacity to one child may well represent 50% to another, depending on the size of that child.

Taking into account the factors of cooperation, convenience, size effects and the type of question to be answered, a simple type of progressive exercise test has been developed by Godfrey et al. (1971) which lasts from 6 - 9 minutes, regardless of the child being tested.

As with progressive exercise tests, steady-state tests present the problem of which workload to offer children. The object of a steady-state test is to get the child to work at one or more levels which can be sustained long

enough so that valid measurements of work metabolism at that level can be made. The best method of selecting submaximal workloads is to have the child carry out a simple progressive exercise test in order to measure maximum work; steady-state measurements can then be made at rest, and at one-third and two-thirds of the measured maximum work level. These workloads represent "easy" and "moderately difficult" tasks, and the literature (Thoren, 1971) seems to indicate that almost all children can complete both workloads without stopping in between.

Anthropometric Measures

This section deals with those methods and techniques used to assess body composition and maturation. The basic equipment needed is essentially the same whether one is testing in the laboratory or in the field: a stadiometer to measure height and weight, plus calipers to measure subcutaneous fat skinfolds and diameters, and measuring tapes for circumferences.

Many laboratories have included in their inventory of equipment an underwater weighing tank; several also have the capability of measuring body potassium and thus lean body mass. However, an adequate job can be done without use of either of these two items.

Since the size and geometry of the body impose constraints upon one's capacity for motor performance, identification of the extent of these constraints is a part of the process of testing and analyzing motor development.

There are two basic uses for anthropometry. First, to determine the level of maturation of the child, so that performance may be more accurately judged. The most sophisticated method of determining maturation is by use of radiography (i.e., X-ray evaluation of the epythisial closures of the long bones). The results of this radiographical analysis can be compared with sets of published norms (Tanner et al., 1962).

Since this method is normally not available to most researchers, an adequate and fairly accurate estimation of maturation can be obtained from a measure of standing height.

Beyond measures of height and weight, measurement of various subcutaneous fat skinfolds allows one to determine body density, and hence body composition.

Although much of the literature deals with the determination of body composition in adults, there is now more information available on children. For example, Cureton et al. (1975) offer a prediction equation utilizing the sum of 10 skinfolds to determine body density.

In summary, while many consider that the assessment of body composition is somewhat "exotic," it has become evident that this area of measurement cannot be ignored if one expects to accurately assess performance of children.

Summary

Several methods and techniques in the areas of physiological and anthropometric measurement have been described as examples of the wide range of methodology available to both the researcher and the practicioner who would attempt to assess the physiological aspect of motor developmental status and progress in children.

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